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Abstract: Rapidly expanding energy development in western North America poses a major new challenge for conservation of Greater Sage-Grouse (*Centrocercus urophasianus*). We reviewed the scientific literature documenting biological responses of sage-grouse to development, quantified changes in landscape features detrimental to sage-grouse that result from development, examined the potential for landscape-level expansion of energy development within sage-grouse range, and outlined recommended landscape-scale conservation strategies. Shrublands developed for energy production contained twice as many roads and power lines, and where ranching, energy development, and tillage agriculture coincided, human features were so dense that every 1 km2 could be bounded by a road and bisected by a power line. Sage-grouse respond negatively to three different types of development and conventional densities of oil and gas wells far exceed the species' threshold of tolerance. These patterns were consistent among studies regardless of whether they examined lek dynamics or demographic rates of specific cohorts within populations. Severity of current and projected impacts indicates the need to shift from local to landscape conservation. The immediate need is for planning tools that overlay the best remaining areas for sage-grouse with the extent of current and anticipated development. This will allow stakeholders to consider a hierarchy of set-aside areas, lease consolidations, and more effective best-management practices as creative solutions to reduce losses. Multiple stressors including energy development must be managed collectively to maintain sage-grouse populations over time in priority landscapes.

Regarding the effects of power poles and related infrastructures on sage-grouse the authers state the following: Males and females may abandon leks if repeatedly disturbed by raptors perching on power lines near leks (Ellis 1984), by vehicle traffic on nearby roads (Lyon and Anderson 2003), or by noise and human activity associated with energy development (Braun et al. 2002, Holloran 2005, Kaiser 2006). Collisions with power lines and vehicles, and increased predation by raptors may also increase mortality of birds at leks (Connelly et al. 2000, Lammers and Collopy 2007). Roads and power lines may also indirectly affect lek persistence by altering productivity of local populations or survival at other times of the year. Sage-grouse mortality associated with power lines and roads occurs year-round (Aldridge and Boyce 2007).

In their study on rangelands with energy development contained twice the density of roads (1.57 vs. 3.13 km/km^2) and powerlines (0.27 vs. 0.58 km/km^2) and five times as many ponds (0.12 vs. 0.62 per km^2) as those where ranching was the primary land use. Human features had the highest density where ranching, tillage agriculture, and energy development coincided. At this intensity of land use,70% of the landscape was within 100 m and 85% was within 200 m of a human feature, and densities were sufficiently high that every 1 km^2 of land could be bounded by a road (4.10 km/km^2) and bisected by a power line (0.86 km/km^2).

They conclude the scientific evidence from 1998 to the present that energy development is impacting sage-grouse populations has become apparent. However, questions remain concerning the exact mechanisms responsible for population declines, and manipulative experiments are needed to test the efficacy of mitigation policies and practices. Burying power lines (Connelly et al. 2000), minimizing road and well pad construction, vehicle traffic, and industrial noise (Lyon and Anderson 2003, Holloran 2005), and managing produced water to prevent the spread of West Nile virus (Zou et al. 2006, Walker et al. 2007b) may reduce impacts. Rigorous testing is needed to know whether these or other modifications will allow sage-grouse to persist in developed areas.